

Technical University of Denmark



## Improving Dynamic Range and Precision for Current In-Plane Tunneling Measurements

**Kjær, Daniel; Østerberg, Frederik Westergaard; Hansen, Ole; Hansen, Peter Folmer; Petersen, Dirch Hjorth**

*Published in:*  
59th Annual Conference on Magnetism and Magnetic Materials

*Publication date:*  
2014

[Link back to DTU Orbit](#)

*Citation (APA):*  
Kjær, D., Østerberg, F. W., Hansen, O., Hansen, P. F., & Petersen, D. H. (2014). Improving Dynamic Range and Precision for Current In-Plane Tunneling Measurements. In 59th Annual Conference on Magnetism and Magnetic Materials: Abstracts

## DTU Library

### Technical Information Center of Denmark

---

#### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Keywords: MRAM metrology, magnetic tunnel junctions, resistance area product, 4-point probe measurements.

## Improving Dynamic Range and Precision for Current In-Plane Tunneling Measurements

Authors: Daniel Kjaer, Frederik Westergaard Østerberg, Ole Hansen, Peter Folmer Nielsen and Dirch Hjorth Petersen

For the past decade the Current In-Plane Tunneling (CIPT) technique [1] has been the metrology of choice for characterization of un-patterned magnetic tunnel junctions (MTJ). In this technique a theoretical model is fitted to a series of 4-point measurements obtained with different electrode pitches, to extract the transfer length  $\lambda \sim \text{RA}^{1/2}$  characteristic of the MTJ and in turn calculate the resistance-area product (RA) and the derived tunneling magnetoresistance (TMR).

The CIPT technique is most commonly used for characterization of MTJ used for either MRAM or hard disc read heads for which the typical MTJ transfer length is in the range 0.5  $\mu\text{m}$  to 5  $\mu\text{m}$ . Usually measurements are performed with micro 12-point probes (see insert in Fig. 1) with electrode pitch ranging from 1.5 to 8  $\mu\text{m}$ , and restrictions on the probe dimensions limit the dynamic range of the method. As previously demonstrated positioning errors of the electrical contacts constitutes the dominant source of errors for 4-point probe measurements at this length scale [2].

Here we demonstrate how the dynamic range and precision of the CIPT technique can be greatly improved by implementation of position correction strategies. Two such strategies have been proposed to lower the effect of positional errors of 4-point measurements on single sheet thin films by utilization of dual-configuration resistance measurements [3,4]. One of the proposed strategies is the van der Pauw correction modified for collinear 4-point probes, whereas the second strategy is a first order approximation thereof.

We provide a comparative study of the two CIPT strategies and the uncorrected single-configuration standard method. Monte Carlo simulations are carried out to evaluate the measurement precision and accuracy of RA (Fig. 1) and TMR from experimentally determined electrode position errors [2] and electronic noise. We find that a modified van der Pauw correction systematically gives the best measurement precision and dynamic range and verify our finding by applying the methods to experimental data from more than 6000 individual MTJ measurements.

Figure 1: Monte Carlo simulation of CIPT measurement precision vs. transfer length using a standard micro 12-point probe (see insert).

References:

- [1] D. C. Worledge and P. L. Trouilloud, Appl. Phys. Lett. 83, 84-86 (2003).
- [2] C. L. Petersen et al., Mater. Res. Soc. Symp. Proc. 738, 157-162 (2003).
- [3] R. Rymaszewski, J. Phys. E. 2, 170–174 (1969).
- [4] D. C. Worledge, Appl. Phys. Lett. 84, 1695-1697 (2004).